

COMMONWEALTH OF PENNSYLVANIA.

DEPARTMENT OF AGRICULTURE.

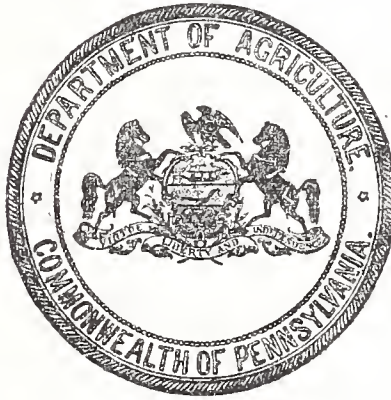
BULLETIN NO. 79.

RABIES,

BY

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of Pennsylvania.*

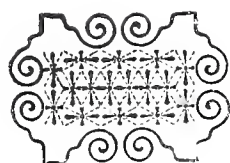


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PREFACE.

Harrisburg, Pa., July 1, 1901.

The following Bulletin, No. 79, on Rabies, by Mazyck P. Ravenel, M. D., Bacteriologist of the State Live Stock Sanitary Board of Pennsylvania, was prepared at the request of the Department of Agriculture, partly for the purpose of correcting erroneous views on the part of some members of the medical profession, as to rabies being a distinct disease, and partly to call attention to the prevalence and dangerous character of this disorder.

In this, as in most other problems affecting the public health, the solution lies largely in prevention, and when people come to realize more fully their danger from hydrophobia, they will be more cautious in dealing with animals showing symptoms of rabies, and by confining such as are suspected of being affected, will assist in eradicating the disease.

Dr. Ravenel has had extended experience in diagnosing cases of rabies, and is, therefore, both by personal experience, as well as by careful study of the subject, thoroughly conversant with the facts which he relates.

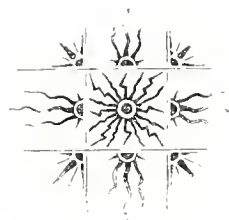
The Bulletin is issued in the hope that it may protect live stock, and also save human life.

JOHN HAMILTON,
Secretary of Agriculture.



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RABIES.

SYNONYMS :

English, hydrophobia, madness; French, rage and hydrophobie; German, hundswuth, tollwuth, wuthkrankheit and wasserscheu; Italian, idrofobia and rabbia Lyssa.

Rabies is an acute and very fatal disease, communicated from animal to animal, or from animals to man by the bite of an animal which already has the disease. As seen under natural conditions, it is always an inoculation disease, that is, communicated directly through a wound usually inflicted by the teeth, and the infective material being the saliva, which contains the poison or virus.

HISTORY. The history of rabies dates back into remote times, having been described distinctly by Aristotle, who lived in the year 326 B. C. He said: "Dogs suffer from madness, which puts them into a state of fury and all the animals that they bite when in this condition become also attacked by rabies." References to it are found in many of the authors prior to the Christian era, and from that date up to the present time, with the exception of the Middle Ages. In the first century of the Christian Era, we find the first description of rabies in the human being and the name "hydrophobia" given to it; this name being by common usage at the present time properly restricted to the disease as seen in man. The term means "fear of water," a symptom seen often in man, though not always, and which is not at all characteristic of the disease. It is not observed in the lower animals, and mad dogs will often lap water, and will even swim across streams.

As early as 1591, we find recorded the transmission of the disease by wolves to man. In 1803, and for a number of years following, it was epizootic among foxes in southern Germany and Switzerland.

During the later years of the eighteenth and the beginning of the nineteenth century the disease spread over the whole of Europe, and about this time made its appearance in America, the first outbreak in America being reported from Boston, 1768. In 1770-1771 it was observed in dogs and foxes in the vicinity of Boston; in the year 1779 it appeared in Philadelphia and in the State of Maryland, and in the year 1785 it was prevalent throughout the northern States, and soon after this time spread to the southern part of this country. During the last century it has inflicted severe losses throughout Europe, including England, and in America.

Its fatal character in animals, and especially in man, has attracted the careful study of many of the most able men who have ever adorned the ranks of the medical and veterinary professions. Among the famous men who gave great attention to it may be mentioned the great surgeon, John Hunter in England, Viborg in Copenhagen, Waldinger in Vienna, Hertwiz in Germany and Pasteur in France. Without detracting in the least from the great work of other investigators, we may say that to Pasteur and his co-laborers, Nocard and Roux, we owe most of the knowledge which we have of the disease at the present day.

DISTRIBUTION. At the present time rabies is known in almost every country on the globe, Australia being the only one which is absolutely exempt, owing to the rigid quarantine enforced against the importation of dogs. It is most common in France, Belgium and Russia. In the latter country it is perhaps more often seen in wolves than any other part of the world. In Holland, Denmark and Sweden it is very rare. In England it has from time to time been wide-spread, but at the present time, owing to strict measures, it has been practically stamped out.

The careful inquiries of Dr. Salmon, Chief of the Bureau of Animal Industry, show that rabies is seen in practically every part of the United States. The census for 1890 reported 143 deaths in man, distributed in thirty States. The figures for the census of 1900 are not available, but Dr. Salmon has collected from health officers the reports of 230 deaths occurring in seventy-three cities since 1890.

There is no systematic report of rabies in the lower animals in Pennsylvania, or any other State, so that it is impossible to give any idea of the number of dogs or other animals affected yearly. There is no doubt, however, that the disease is more prevalent than is generally believed, and there is good reason to fear that it will increase until uniform and efficient laws are adopted for its suppression. The laboratory of the State Live Stock Sanitary Board has investigated 82 cases of rabies, as proven by inoculation and microscopic examination, since October, 1897. Of these 58 were dogs, 4 horses, 17 cows, 1 cat and 2 human beings. All of these except six dogs and one person were from the State of Pennsylvania. A number of other cases have been seen in dogs at the Hospital of the Veterinary Department of the University of Pennsylvania during the past three years.

It is impossible to say what relation these recorded cases bear to the total number which have occurred throughout the State during the same period of time, but they indicate that the disease is more common than is generally suspected.

ANIMALS AFFECTED. All mammals, including man, are liable to rabies. Birds also may contract the disease. The dog is the

animal most constantly affected, but it is seen not infrequently in wolves, foxes, hyenas and jackalls. Rabies in the cat is relatively rare and usually caused by the bite from a dog with which it is associated. Cattle, sheep and goats are affected in relatively about the same degree, cattle and sheep being especially exposed. It is more rarely seen in the horse. Swine contract the disease less frequently than other domestic animals.

The money losses from this source reach a very high figure. In the State of Pennsylvania the loss of stock each year is not inconsiderable, although not reaching a very high figure. During the past year in one herd of sixty cows, eleven died of rabies, worth about \$600.00. Several outbreaks have occurred also among sheep, in one flock twenty out of fifty having died.

In England the losses among deer in several parks have been very heavy. In 1889 rabies appeared among the fallow deer at Richmond, and soon after in the park of the Marquis of Bristol. In the course of three months more than 450 died out of the herd, which contained between 600 and 700 animals.

The disease is rarely transmitted from one of the domestic animals to another. Bites from these animals are less dangerous than from dogs on account of the blunt character of their teeth, which inflict contused wounds rather than punctured ones. The disease may, however, be transmitted in this way, and also by the deposit of virulent saliva on wounds of the skin by licking. Deer are said to be able to transmit the disease to others by biting.

CAUSE OF THE DISEASE. NATURE OF THE VIRUS. Although we have every reason to believe that rabies is due to a specific germ, all attempts to isolate it have so far failed. We, however, understand much of the nature of the virus, the condition which affect it, etc.

In rabid animals it is found principally in the saliva and in the central nervous system, although it is known to pass sometimes into other glands as the lachrymal and pancreas and also into the milk. It has never been found in the blood or in any of the organs such as the liver, spleen and kidneys, nor is it ever contained in the muscular tissues. The contents of the stomach may contain it, owing to the swallowing of the saliva previous to the paralysis of the throat. It affects principally the central nervous system, and it is found most certainly, and in the most concentrated condition in the medulla oblongata. The virus may be present in the saliva for at least three days before the animal shows any symptoms of madness, as proven by Roux and Nocard, and, perhaps, as long as eight days. It may be present in the central nervous system

for two days before the appearance of symptoms. The symptoms do not show themselves until the poison or virus has remained in the nervous tissues long enough to bring about changes in their structure and functions.

Method of Invasion. When introduced into another animal either experimentally or in the natural course of the disease, the virus remains for a time without producing either local or general symptoms, undergoing a period of incubation during which it undoubtedly multiplies itself, in this respect corresponding to the well known infectious diseases. It may be removed from the saliva by filtration through porcelain, proving that it is a solid body. The virus penetrates to the nervous system by following the nerve trunks from the site of injury to the spinal cord, then the spinal cord to the medulla and brain. This has been proven by inoculating an animal in one of its legs with virulent material. After a suitable time, but before the symptoms of rabies appear, if the animal be killed, the virus will be found in the nerves of the limb, and even in the part of the spinal cord into which the nerves enter, while the upper part of the cord and brain will be free from it. This fact explains the reason why the earliest symptoms, both in man and animals, such as pain, itching, tingling, numbness and other nervous sensations, often appear in the part of the body which received the virus through the bite. In the case of a bite about the face and head the route along the nerves to the central nervous system is shorter still. While the nerves then form the main route by which the virus travels, the circulation may at times assist, especially in small animals. Inoculation into the large nerve of the leg is almost as certain to produce the disease, as inoculation directly into the sub-dural space, while injection beneath the skin of the leg is not so sure.

Resistance of Virus. The action of the virus is destroyed by drying, and by the action of light. In dry air protected from the light and from putrefaction, the virulence of the spinal cord of rabbits is destroyed in fourteen to fifteen days. When spread in thin layers the virus is destroyed entirely by drying in four to five days. Sunlight destroys it in about forty hours. The loss of virulence by drying is gradual and quite regular, and this is taken advantage of in the preparation of the "vaccine," which is described later. The virus may be preserved unchanged in neutral glycerine at ordinary temperature for a long time. Roux found that after four weeks in glycerine at 30 degrees C., the virus has the same power as when perfectly fresh.

It is quite resistant to putrefaction. Galtier has found the virus active in the central nervous system of rabbits buried for twenty-

three days, of sheep buried thirty-one days, and of dogs buried forty-four days. Other observers have found it still active in animals buried for twenty-four days.

It is destroyed completely by a temperature of 50 degrees C. (122 degrees F.) in one hour, or 60 degrees C. (140 degrees F.) in one-half hour. It is uninjured by exposure to extreme cold, resisting the prolonged application of a temperature from 10 degrees to 20 degrees below zero, centigrade.

Its activity is destroyed in one hour by a 5 per cent. solution of carbolic acid, or by a 1 to 1,000 solution of corrosive sublimate. Water saturated with iodine destroys it in ten minutes.

DANGER FROM BITES. The danger of infection as well as the time elapsing between the introduction of the poison and the development of the disease is dependent upon a number of factors. The disease appears more quickly in children than in older persons, and for obvious reasons they are more often attacked by dogs, and the bites are more apt to be on the face and head. Wounds about the head and face are particularly dangerous, next comes bites about the hands, and lastly, other parts of the body. The richer the nerve supply of a part the greater the danger. Punctured wounds are most dangerous, and lacerated wounds are dangerous in proportion to the extent of the surface afforded for the absorption of the virus. The danger of infection varies with the animal which inflicts the bite. First, comes the wolf; second, the cat; third, the dog, and, fourth, other animals. In the western part of the United States the skunk is said to be very liable to the disease, and the bite from this animal is quite dangerous. Bites on naked or exposed parts of a person are more dangerous than through clothing, in the latter case the virus being wiped off and not gaining access in quantity to the tissues. The same thing is observed among the lower animals, as dogs with long hair, like the spaniel and the collie, are less liable to the disease than are short-haired dogs. Experimentally, it has been shown that rabbits which are shaven and exposed to the bite of a mad dog are more often affected than are those bitten through the fur, even when the teeth penetrate deeply beneath the skin. The proportion of persons who contract hydrophobia after being bitten by mad dogs, and are not treated, is conservatively estimated at 16 per cent., but some series of cases give a much higher mortality. Thus, of 855 cases collected by Tordieu, Thamhayn and Bouley, 399 ended in death, or 46.6 per cent. In another series of cases given by Bouley, out of 266 persons bitten, 152 died of hydrophobia; but of these, 120 were bitten on the face and hands, the greater danger from which has been mentioned.

The mortality following bites from wolves is placed at from 60 to 80 per cent., the increased danger from these animals being due

partly to the greater activity of the virus as found in them, and partly to their mode of attack, wounds about the face and heads being common, and the wounds being very extensive.

Of animals bitten by rabid dogs, it is claimed that only from 20 to 30 per cent. become infected. Röhl calculated that during the years 1877-1887 the percentage in horses was about 40, among cattle and sheep, 50, among pigs, 36, and among goats, 20. It will be seen from these figures how unnecessary it is to destroy all animals bitten by dogs believed to be or even known to be made.

PERIOD OF INCUBATION. By the period of incubation is meant the time which passes between the introduction of the virus or germ of a disease, and the appearance of the symptoms. This is quite variable in rabies, depending on the site of the wound, which is almost always a bite, the amount of virus introduced, and the strength of the virus. In general it may be said for all animals that the period of incubation seldom exceeds sixty days, though in man and in some of the larger animals, it sometimes, though very rarely, reaches one year. The average period is as follows:

In man, 40 days.

In dogs, 21 to 40 days.

In horses, 28 to 56 days.

In cows, 28 to 56 days.

In cats, 14 to 28 days.

In pigs, 14 to 21 days.

In goats and sheep, 21 to 28 days.

In birds, 14 to 40 days.

INFLUENCES OF SEASONS. It has been for a long time believed, and apparently with a certain degree of truth, that rabies in dogs is more frequent during the hot months than at other periods of the year, and as a result of this we would expect to find more persons bitten during the periods of extreme heat than during the rest of the year. The old statistics in France, dating from the year 1850 to 1876, indicate that 30.4 per cent. of all cases of rabies occurred during the months of June, July and August. The figures collected at the Pasteur Institute in Paris do not, however, agree with these, the maximum number of bitten persons applying for treatment there during the years 1886 to 1893 being in March, April and May, and the minimum number in September, October and November. The statistics collected by Bouley give for December, January and February, 755 cases; March, April and May, 857 cases; June, July and August, 788 cases, and September, October and November, 696 cases, showing a fairly uniform distribution for the whole year. The maximum number, occurring during March, April and May, agrees with the figures of the Pasteur Institute.

I quote a table compiled by Dr. Salmon, Chief of the Bureau of Animal Industry, giving the occurrence of 14,066 cases by months:

CASES OF RABIES IN DOGS. BY MONTHS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Bourrel,	36	31	26	32	32	42	32	30	37	41	24	32	333
Saint Cyr,	12	15	6	15	13	7	4	9	1	3	.....	2	87
Hogyes,	309	310	314	367	450	502	580	537	455	438	333	396	4,961
Leblanc,	103	97	121	192	155	138	147	123	114	117	95	100	1,492
France:													
1895,	89	155	153	184	181	129	157	147	133	110	105	149	1,692
1896,	124	138	151	150	147	199	138	117	131	125	103	164	1,687
1897,	131	151	189	202	225	172	192	154	136	131	150	140	1,973
1898,	139	148	.....	181	216	278	185	177	150	.....	153	154	1,781
Total,	943	1,045	960	1,323	1,419	1,467	1,435	1,294	1,145	965	933	1,137	14,066

The highest number of cases occurred in June, and the smallest number in November. Taking the total result as given by this table, in connection with the other figures quoted, it may be said that more cases of rabies occur from April to September, inclusive, than during the rest of the year. In giving a proper value to these figures it must be noted that during the warm months of the year, dogs are more apt to be running abroad, while during the winter months they are more apt to be housed. In this way opportunities for contagion are greater from April to September than from October to March, and there is no evidence that of itself that season has anything to do with the greater or less frequency of rabies.

ERRONEOUS IDEAS CONCERNING RABIES There is a rather widespread belief that if a dog which has bitten a person ever goes mad the bitten person is also liable to go mad, and this superstition leads to the useless destruction of a considerable number of dogs. It probably has its origin in the fact that the virus is present in the saliva for several days before symptoms of madness are shown by the dog, and that certain persons have contracted hydrophobia following the bite of such an animal, which, at the time, showed no symptoms of madness. It can be stated with the most absolute certainty that the bite of a healthy dog, or a dog suffering from fits, or when angered or excited, can produce no ill effects in the bitten person other than that dependent on the extent of the injury. Such wounds should be treated by modern antiseptic methods, cauterization being unnecessary.

The Mad Stone. Persons bitten by dogs strongly suspected of rabies should at once take the advice of a competent physician, and if the diagnosis is confirmed, go as rapidly as possible to some institution where the Pasteur treatment can be applied. No dependence whatever can be placed upon the so-called "mad-stones."

Pseudo-Hydrophobia, or Lyssophobia. It is to be regretted that the opinion is so wide-spread, even among some physicians, that fright following the bite of a dog can bring about symptoms of hydrophobia, followed by death. It cannot be denied that such symptoms do sometimes occur in persons bitten by dogs known to be free from hydrophobia, but the writer has failed to find reliable report of any death in such cases. Recovery usually takes place in a few days under very simple treatment, though the symptoms sometimes persist for a considerable time, ending, however, in complete recovery.

Can Rabies or Hydrophobia Arise Spontaneously? It is supposed by some persons that rabies can be produced by fright, fatigue, anger, jealousy, high feeding, excessive heat and other influences—an error which was pointed out by Virchow in Germany many years ago.

After what has been said of the nature of the virus it is manifest that this is impossible. Each case of rabies is due to contagion from some other case just as truly as each case of measles or scarlet fever in children is due to the germ from some other case gaining entrance to the system. Rabies cannot arise of itself from any cause.

Dog Days. The belief that dogs are particularly apt to go mad during the so-called dog-days is shown by the law, still enforced in some places, requiring the muzzling of dogs during this period. As has been shown in another part of this article, rabies occurs during every month of the year.

The term “dog days” refers to the “dog star,” Sirius, and was originally applied to the period of time during which the dog star was above the horizon with the sun. At present they are usually reckoned from July 3 to August 11, inclusive. Dogs are not more liable to go mad during this period than at other times.

RABIES IN MAN. The course of the disease in man may be divided into three stages, a premonitory stage, a stage of excitement and a paralytic stage.

In the first stage there is usually irritation about the point of inoculation, or else pain, numbness or a tingling sensation; depression and melancholy are observed, the disposition becomes irritable, and there is a sense of great fatigue with restlessness and often a feeling of impending danger; the sensibilities are increased, noise or light causing distress. The first difficulty in swallowing may appear. During this stage the voice becomes husky. The pulse and temperature are increased.

In the second stage the chief symptoms are great excitability and restlessness, and hyperaesthesia is marked: “Any efferent stimulant—i. e., a sound or a draught of air, or the mere association of a verbal suggestion—will cause a violent reflex spasm. In man this

symptom constitutes the most distressing feature of the malady. The spasms, which affect particularly the muscles of the larynx and mouth, are exceedingly painful and are accompanied by an intense sense of dyspnoea, even when the glottis is widely opened or tracheotomy has been performed." (Horsley.) These spasms are brought on by any attempt to drink water, or by touching with a wet towel, and so painful is the result that patients come to dread the sight of water or even liquids of any sort. It is from this symptom that the name of hydrophobia (dread of water) is derived. There may be maniacal symptoms with the spasms, and occasionally furious mania is seen. This is exceptional, however. During the spasms difficulty of breathing occurs, and curious sounds may be uttered from which the exaggerated reports of people barking like dogs arise. This stage lasts from a day and a half to three days and is succeeded by the final or paralytic stage, which ends in death in from six to eighteen hours, the heart's action becoming more and more feeble and death occurring from syncope.

Rupture of the muscles during the convulsions may take place and give rise to distressing symptoms. Emphysema, or a filling up of the loose tissues under the skin with air coming from the lungs through tears in the pleurae also occurs at times.

RABIES OF THE DOG. The disease is seen in two types, a furious, and tranquil or paralytic type.

Furious Type. In the furious type the first symptoms consists solely in changes in the disposition of the animal, which are manifested by distress or uneasiness, and restlessness. He is always easily excited. At this stage, the animal does not usually show a disposition to bite; he is still docile and obeys orders, though not so quickly as in health; he soon seeks solitude and shows a disposition to hide in dark corners, or burrow in the straw of his kennel; periods of calmness alternating with marked excitement are observed; he still shows affection for his master and may respond to caresses even more affectionately than is his wont. He may, however, be irritated by strangers, or being surprised by touch or blow, may inflict a bite. The appetite is still good and may be even excessive. Soon the restlessness becomes more marked; the dog is constantly in motion; he is apt to tear carpets, rugs, etc., which may be in the room with him; he shows signs of delirium, looking off into space, apparently seeing some imaginary object; at times he will attack an imaginary enemy. He will still respond to his master's voice, but his attention cannot be held for any length of time. At this early stage, the voice becomes modified, and this may be regarded as one of the most typical symptoms. Instead of the clear and sharp bark which is natural, the latter part of the note becomes prolonged and of a higher pitch, going off into a plain-

tive cry, which has been likened to that of a dog fatigued in the chase, and in succeeding short barks which may follow, the jaws do not close completely as in ordinary barking.

While this symptom is a striking one and quite constant, it may be lacking at times and certain dogs remain quiet in spite of all attempts to excite barking. The appetite diminishes about this time; food is taken with more or less difficulty, and soon it is refused, swallowing having become painful and difficult. The animal may appear to have a bone stuck in its throat, a symptom which often tempts the owner to make the dangerous examination for some obstruction. There is no fear of water, and the animal drinks water and other liquids quite greedily, until paralysis of the constrictor muscles of the pharynx makes swallowing impossible.

The excitation becomes marked and the animal is now furious. If a stick or other article is presented to him he seizes it with power; he attacks the bars of his cage or any object in the cage. If at liberty, he attacks every object in his way, swallowing all sorts of articles, such as wood, paper, straw and stones, the presence of which in the stomach after death is one of the most striking features of the disease. At this time he begins to wander, running with his tail hung, the mouth open and the eyes with a wild look; he attacks every object or animal which comes in his path. As a rule, he runs straight ahead and does not turn out of his way to attack animals. The dog may travel tremendous distances, but is apt to return to his home, exhausted and covered with dust and blood, or else he may continue his course until he falls exhausted, as much as fifty miles being covered. Very soon paralysis sets in, commencing in the hind legs, and finally becomes general. The dog is no longer able to stand; the weakness becomes more marked and stupor sets in, from which the animal may be aroused, but which becomes deeper and deeper, and ends in death. The course of the disease is always rapid, covering from six to ten days, and averaging from four to five days. The symptoms are so characteristic that once seen can scarcely be mistaken for any other disease. The furious type just described is the most common.

Paralytic Form. The paralytic type, ordinarily spoken of as "dumb rabies," constitutes from 15 to 20 per cent. of all cases. In certain countries, as in Turkey, it is the prevailing type, which explains the relative rarity of rabies in man in this country where dogs abound. The commencement of the disease is the same as in the furious type, but the accesses of fury are lacking. For several days the dog appears restless, seeking seclusion and dark places. The paralysis may commence in various parts of the body, but, as a rule, affects first the muscles of the jaw, which soon drop, the dog being unable to close its mouth, and the tongue hanging out;

the whole expression of the animal is pitiful in the extreme; an abundance of saliva runs from the mouth; the taking of water is impossible; the mouth becomes dry and covered with dust, and brownish. The animal is quiet; it does not respond to provocation, nor does he seem to wish to bite. The progress of the disease is more rapid than in the furious type. The paralysis extends and death occurs on the second or third day.

Other cases are observed in which the type of the disease is more or less intermediate between the two just described. There are some in which a very short period of fury is followed by a rapid paralysis, while in others the paralysis is more slow in its progress and the animal shows a slight disposition to attack when irritated. In the "dumb" type of the disease it is common to suspect an obstruction in the throat, and in the attempt to locate it the saliva may infect wounds of the hand. The animal never wanders and, being unable to bite, the danger of transmission of the disease is slight.

RABIES OF THE CAT. This animal shows first a period of restlessness, with a disposition to hide in dark corners. It soon becomes furious and leaves its place of retreat and is liable to attack any one who comes within its reach. The bites inflicted by it are, as a rule, very serious. It shows the same perversion of appetite as seen in the dog. After five or six days paralysis of the hind legs begins; swallowing becomes impossible and death soon follows. The paralytic form, or "dumb" rabies also occurs, causing death in from three to four days.

RABIES OF THE HORSE. In the horse, excitement is an early symptom, with a marked sensitiveness of the skin, and hallucinations. If it can reach the point of inoculation, it bites itself constantly, tearing the skin and often the deep tissues. The appetite ceases, or becomes capricious and irregular. Like the dog he eats earth, wood or anything within his reach. In the attempt to swallow water it may be thrown out through the nostrils. A slight annoyance renders the animal furious and he attacks with ferocity any animal or person. The attacks of fury become more and more frequent. The pulse may reach 100 to the minute, and respiration is difficult. Paralysis commences in the limbs and soon becomes general. Death occurs from asphyxiation in from three to six days.

RABIES OF THE DOG. The symptoms in these animals are much the same as those just described. There is often an intense irritation at the site of the wound. Changes in the appetite occur and rumination stops. In about twenty-four hours after the appearance of the first symptoms, fury becomes manifest; there is bellowing, and hallucinations, which are evident from the aspect of the countenance as well as the actions. Swallowing becomes difficult, saliva

flows in abundance from the mouth. Waving the hand or a stick at the animal is sufficient to make it attack. In the intervals of fury the animal is somnolent, dull. Death usually occurs by paralysis, starting often in the limb which was bitten. The animal soon becomes prostrated and dies on the fifth or sixth day. In these animals, as in others, the paralytic or "dumb" form is seen also.

The symptoms as seen in goats, deer and sheep do not differ materially from those already described.

A symptom more or less common to all animals is the irritation about the site of the inoculation wound, this being often the earliest symptom which attracts attention.

RABIES OF BIRDS. The disease in birds is apt to be of the paralytic type, and its duration is more chronic than in any animal, lasting from fourteen days to several weeks, and occasionally ending in recovery. The crow, falcon and old pigeons are refractory to the disease, while chickens, geese, owls and young pigeons contract it readily. The period of incubation in geese and owls is about fourteen days, while for the chicken it may reach forty days. The degree of virulence of the virus with which the inoculation is made seems to have but little effect on the rapidity of incubation. The blood serum and brain matter of birds which resist the disease destroy the virus. The changes in the central nervous system are the same as those which have been found in man and in the domestic animals, and are especially marked when the disease is slow in its progress.

APPEARANCES AFTER DEATH. There is no change in animals which have died of rabies which can be considered specific of the disease. The cadaver is apt to be emaciated and becomes putrid rapidly. The blood is dark and thick; the brain and its membranes may be congested, even show slight hemorrhages, and the respiratory and digestive tracts show a catarrhal condition, with slight hemorrhages. Perhaps the most constant feature is the presence of foreign bodies such as wood, straw, hair, etc., in the stomach and the absence of food, this condition having been found in 90 per cent. of 200 cases in dogs examined by Axe.

The absence of changes, which may be considered as belonging specifically to rabies, is no doubt due many of the erroneous ideas which have been held concerning the disease.

Until recently, the only way of making a certain diagnosis after death, was by the inoculation of other animals with a portion of the brain or spinal cord of the dog. For this purpose the rabbit has been usually selected, as being one of the most susceptible of all animals to the disease. Injections into the muscular tissues of any part of the animal with the virus of rabies, will almost certainly produce the disease, but it is more quickly produced by inocu-

lation beneath the membranes of the brain. For this purpose a small button of bone is taken from the skull, just large enough to admit the insertion of a hypodermic needle, and three or four drops of a suspension of the brain, made by rubbing with water in a mortar, is introduced. The wound in the skin is washed with carbolic acid and then sealed with collodion and cotton. The rabbit shows no inconvenience from the operation whatever, and will eat and play within a minute after its completion. If the operation is done in a cleanly manner, and the material is fresh and has not undergone decomposition at all, no ill effects are observed until symptoms of hydrophobia present themselves. This seldom occurs in less than three weeks, and may not take place until sixty days have passed. The symptoms as seen in the rabbit are well defined and entirely diagnostic. The form of the disease in rabbits after such inoculation is almost always the paralytic, though at times the animals become furious, biting a stick or any other object within their reach. Before the death of the animal its symptoms are carefully noted, and after its death the brain and organs are examined, and cultures made from the blood and all organs, with the object of making sure that the animal died of hydrophobia, and not of some accidental infection, in which case the germ producing that infection would be manifest in the cultures. When the inoculated animal dies before the fourteenth or fifteenth day we may be reasonably sure that it has not died of rabies, but as a result of the operation. This examination can be carried out properly only by those who have had special training, and should not be attempted by others.

MICROSCOPIC EXAMINATION. In a disease marked by such striking symptoms referable to the nervous system, it is natural to expect that changes would be found in the central nervous system sufficient to account for the production of symptoms. As well stated by Babés, "this disease so clearly characterized by a train of symptoms, constant in their character, ought also to present characteristic lesions in the nervous centers, and especially in the ganglia which preside over the production of symptoms." Numerous studies have been undertaken by workers in various parts of the world, with the object of discovering some change in the nervous system which could be considered as belonging especially to rabies, but while changes were found, none of them could be considered as specific.

RECENT ADVANCES IN OUR KNOWLEDGE. During the year 1900, the discovery of changes distinctive of rabies was announced by Van Gehuchten and Nélis. These changes are found in the peripheral ganglia of the cerebro-spinal and sympathetic systems, and are especially marked in the plexiform ganglion of the pneumogastric nerve and the gasserian ganglion. Normally, these ganglia, are

composed of a supporting tissue holding in its meshes the nerve cells, each one of which is enclosed in a capsule, made up of a single layer of endothelial cells. (Fig. 1.) The action of the rabic virus

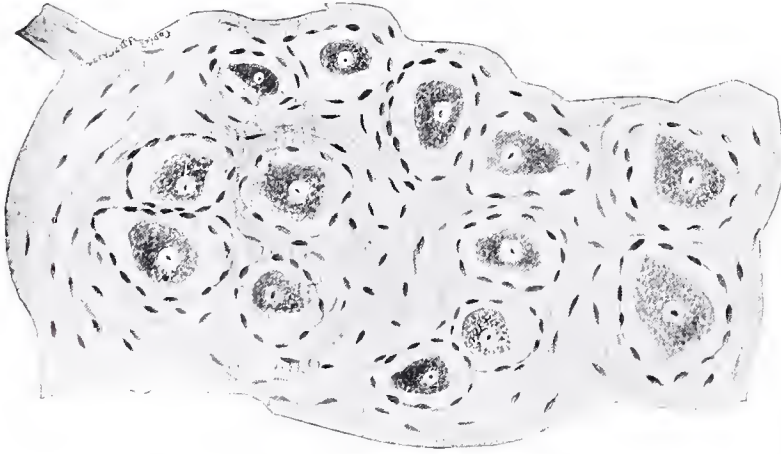


Fig. 1. Normal Ganglion. (Reproduced by Crocq, Journal de Neurologie, Vol. V., No. 13).

seems to exercise its effect on these cells particularly, bringing about an abundant multiplication of the cells forming this capsule, leading finally to the complete destruction of the normal ganglion

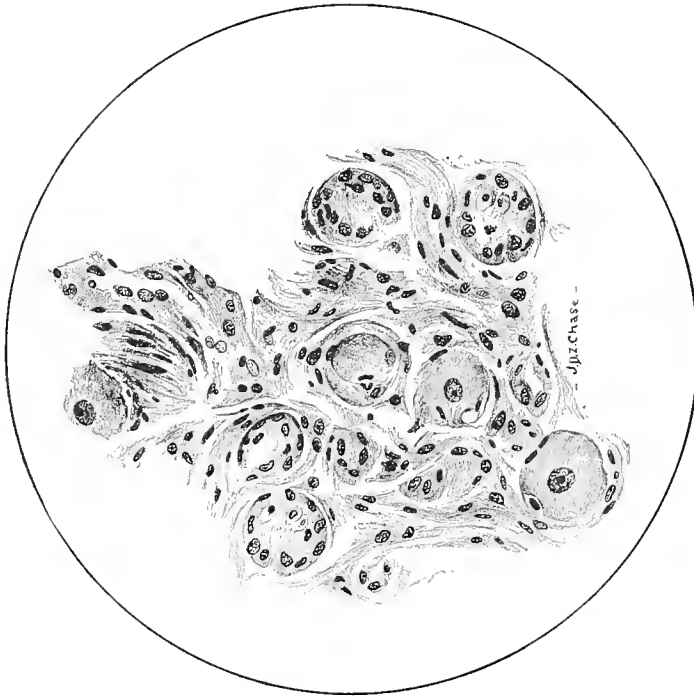


Fig. 2. Plexiform Ganglion of Rabbit, dead of rabies produced by sub-dural inoculation. The capsules are filled, or partially filled by the new formed cells.

cell and leaving in its place a collection of round cells. (Fig. 2.) Ordinarily a considerable number of ganglion cells will be found which have undergone only a slight change, but under certain condi-

tions the process is so widespread that all the ganglion cells are destroyed. The intensity of these changes varies in different animals; they are perhaps most pronounced in the dog, less marked in man and still less in the rabbit.

Much of the value of these findings consists in their affording a quick and sure means of making a diagnosis. It is possible to complete the examination within six hours after the death of the animal, and under ordinary circumstances a positive opinion can be given in from twenty-four to thirty-six hours. It is important that the animal should be allowed to die, and not be killed prema-

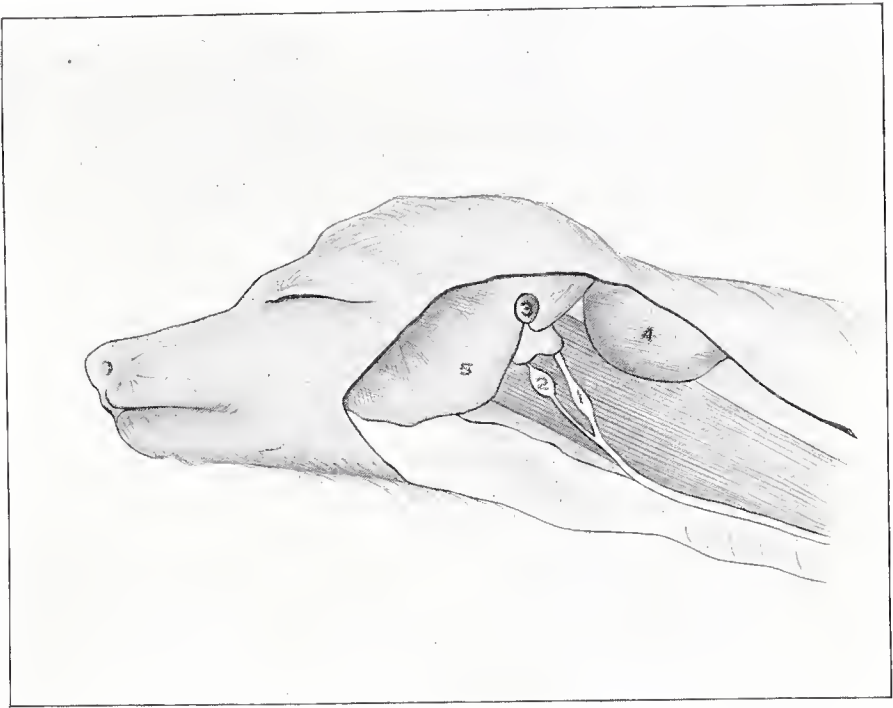


Fig. 3. Dissection of the upper neck of dog, showing the Plexiform Ganglion of the Pneumogastric nerve, in which the changes are usually sought for 1. Plexiform Ganglion. 2. Cervical Ganglion. 3. External auditory meatus. 4. Atlas. 5. Inferior Maxilla. (After Valee-Diagrammatic).

turely, as where the disease is not permitted to run its full course ending in death, the changes may be absent or only slightly developed.

The ganglion on the pneumogastric nerve is selected by preference and should be removed as soon as possible after the death of the animal. (Fig. 3.) It is put into absolute alcohol, or in 10 per cent. formalin solution. If put into absolute alcohol it should be removed to a fresh portion of alcohol at the end of six hours, in which it remains for six hours, when it may be transferred for one hour to a mixture of absolute alcohol and chloroform, and then put for one hour in pure chloroform, then one hour in a mixture

of chloroform and paraffin, and lastly imbedded in pure paraffin. If formalin is used for fixing, the ganglion should be removed at the end of six or eight hours, put for six hours more in 95 per cent. alcohol, and then into absolute alcohol for six hours, after which it may be fixed to blocks for cutting, by mucilage of gum arabic, or else imbedded in collodion. The characteristic changes in the capsule are brought out best by the use of hematoxylin, or hemalum, and eosin. The method of Nissl gives good results also, but as it requires some special technical knowledge to be efficiently carried out, the former is recommended for its simplicity and ease of execution. This method has stood the test in Europe and America for nearly two years, and although a large number of animals having different diseases have been examined with the object of determining whether or not these changes may occur in other conditions, they have never been found.

At the laboratory of the State Live Stock Sanitary Board, which was the first in this country to take up this method, fifty-two cases have been examined since May, 1900, without a single failure. These cases have occurred in mankind, dogs, cows, cats and rabbits, and the characteristic changes have been found in each of these species. We have not had an opportunity of examining horses, sheep or swine. In this laboratory it has replaced the slower and less certain method of inoculation almost entirely. Inoculations are now practised only in those cases in which the material is sent in such condition that the microscopic examinations is impossible.

TREATMENT. When once the symptoms of rabies have manifested themselves, treatment is of little avail, either in man or in animals. Except for the purpose of making a sure diagnosis, animals may be destroyed at once. In man, the only treatment possible is directed to the control of symptoms, such as the spasms, and the relief of suffering. All that can be done is to give anti-spasmodics, such as chloral, bromides and morphine in large doses, or else resort to the inhalation of chloroform. It is better not to waste time by giving the milder anti-spasmodics, but to begin at once with the strong ones like morphine and chloroform, which should always be administered under the direction of a physician.

In birds and animals a few cases of recovery have been observed even after inoculation with the virns in good quantity. In man the disease is uniformly fatal, consequently our measures to be successful must be directed to preventing the development of the disease after inoculation by the bite of a rabid animal.

Pasteur Method. Treatment must, therefore, be preventive and not curative. The only method which is worth while mentioning is that of Pasteur, by which an immunity is produced by the subcutaneous injection of the virus of rabies in an attenuated form,

beginning with the mildest virus and going gradually up to one which possesses full virulence. This attenuation of the virus is brought about by drying at a fixed temperature, and the action of the atmosphere. Depending upon the length of time the virus is exposed to these influences, we can obtain any degree of virulence desired, the loss of virulence under fixed conditions being quite uniform.

The disease as seen in dogs infected naturally was called by Pasteur "street rabies," and the virus from such animals is known as the "virus of street rabies." Such virus will produce the disease in rabbits by intra-cranial inoculation in from three to four weeks as a rule. By inoculating rabbits in series, one from the other, we obtain a reduction in the period of incubation so that after about 100 passages, rabbits will die on the sixth or seventh day after inoculation with great certainty. Beyond this point no increase of virulence can be obtained, therefore, to this virus the name of "fixed" was given. It is with this "fixed" virus that all of our methods of vaccination are carried out.

Preparation of Vaccine. The spinal cord of a rabbit which has died after inoculation with this "fixed" virus is removed with the greatest precaution to prevent contamination. It is then cut into three portions, of equal length, and suspended by a silk thread in a large bottle containing a layer of caustic potash at the bottom. The bottle has an opening near the bottom as well as at the top, both of which are plugged with cotton, to allow a free passage of atmospheric air. These are kept in a dark room at a carefully maintained temperature of 23 degrees C. Under these conditions the cords lose their virulence entirely in about fifteen days. Those kept for fourteen days have a very slight degree of virulence, and furnish our weakest virus with which the vaccination is begun. On succeeding days cords which have been dried for thirteen, twelve, eleven, etc., days, are used, until one which has unimpaired virulence may be injected with perfect safety. The method was tried at first on animals with perfect success, and since 1885 has been applied to persons bitten by rabid animals. The treatment is varied slightly according to the extent of the bites and their location. The simplest form requires fifteen days, the next eighteen days, while what is called the "intensive" treatment, employed where the bites are about the face, and in portions of the body rich in nerve supply, requires twenty-one days. The one most commonly used is given below:

TREATMENT MOST COMMONLY USED—18 DAYS.

Day of Treatment.	Age of the Cord.	Quantity Injected.
1,	{ 14 days,	3 cubic centimetres.
2,	{ 13 days,	3 cubic centimetres.
3,	{ 12 days,	3 cubic centimetres.
4,	{ 11 days,	3 cubic centimetres.
5,	{ 10 days,	3 cubic centimetres.
6,	{ 9 days,	3 cubic centimetres.
7,	{ 8 days,	3 cubic centimetres.
8,	{ 7 days,	3 cubic centimetres.
9,	{ 6 days,	2 cubic centimetres.
10,	{ 5 days,	2 cubic centimetres.
11,	{ 4 days,	2 cubic centimetres.
12,	{ 3 days,	2 cubic centimetres.
13,	{ 2 days,	2 cubic centimetres.
14,	{ 1 day,	2 cubic centimetres.
15,	{ 14 days,	2 cubic centimetres.
16,	{ 13 days,	2 cubic centimetres.
17,	{ 12 days,	2 cubic centimetres.
18,	{ 11 days,	2 cubic centimetres.

RESULTS OF TREATMENT. Since the commencement of the Pasteur Preventive Treatment, some 55,000 persons have been inoculated, the treatment now being administered in twenty-five laboratories in different parts of the world. The total average mortality at all these laboratories is about 0.77 of 1 per cent. This includes a number of people who have been bitten by wolves, the bites of these animals being especially fatal, the mortality reaching as high as 80 per cent. in every 100 bitten. At the parent institute in Paris from 1886 to 1899, inclusive, 23,245 cases have been treated, of whom 103, or 0.44 of 1 per cent. have died. The mortality during the first year was 0.94 of 1 per cent., and has steadily gone down until during 1899 it was 0.25 of 1 per cent., the lessened mortality being due to some extent at least to the smaller number of persons bitten by wolves who have been treated there in late years, owing to the fact that there have been laboratories instituted in other parts of Europe nearer to the regions where wolves abound.

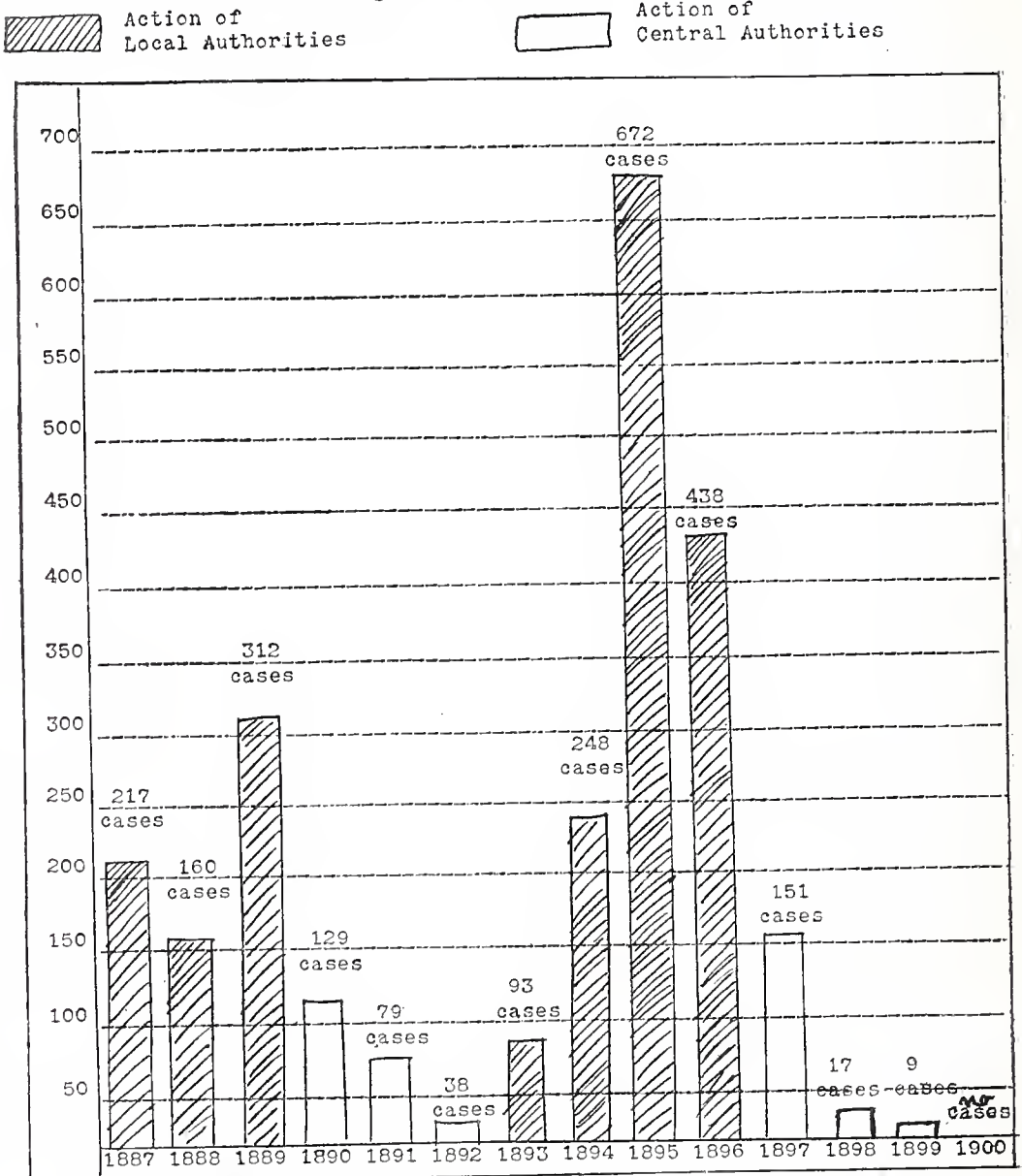
The value of the preventive treatment is well brought out by statistics. In Hungary, from April 15, 1890, to December 31, 1890, 5,899 persons were bitten, of whom 4,914 were inoculated, with a mortality of 1.2 per cent., while the mortality among those who did not take the treatment reached 14.94 per cent. The treatment is absolutely free from danger, and has no ill effects whatever except soreness at the point where the injections are made. Persons undergoing it are not confined to the house, but are able to go backward and forward from their homes to the institution.

Application to Animals. A large number of experiments have proved that the Pasteur treatment is applicable to animals also,

though the shorter period of incubation which is the rule in many of them, makes it less sure, and the expense attending it has prevented its general use. At the Veterinary Department of the University of Pennsylvania it has been successfully applied in several instances, the "vaccine" having been furnished by the New York City Department of Health.

PREVENTION AND ERADICATION OF THE DISEASE. As regards both man and animals the only rational procedure is to attempt the eradication of the disease, and since it is kept alive by the canine race our measures must be directed to the control of dogs. Among the respective measures which have been advocated may be mentioned a high tax, muzzling and the leash. During outbreaks which excite terror in a community we see not unfrequently the enactment of the most extreme measures, such as the destruction of all dogs, which is totally unnecessary. The results obtained by strict enforcement of muzzlings seem to justify its recommendation. To this measure is ascribed the eradication of the disease from Berlin in the year 1854-1855, and the recent results obtained in Great Britain are most striking. The official reports of Great Britain show that in 1887 there were 217 cases of rabies; 1888, 160; 1889, 312. Owing to the alarm caused by this increase, muzzling was adopted, with the result that in 1890, 129 cases were seen; in 1891, 79 cases, and 1892, 38 cases. There was much opposition to the enforcement of the muzzling ordinance and it was relaxed, with the result that in 1893 the number of cases rose to 93; in 1894, to 248 cases, and in 1895, 672 cases were seen. Owing to the alarm muzzling was again enforced, resulting in a great reduction in the number of cases, to 438 in 1896, 151 in 1897, 17 in 1898, and 9 in 1899. From November, 1899, to January 1, 1901, not a single case of rabies has been reported in England or Scotland, according to official statistics just issued for the year 1900.

Table Showing Effect of Enforcement of Muzzling by Central Authorities
in England 1887-1900.



Professor MacFadyean says in his report: It appears probable that the past year (1900) will remain memorable as the one in which rabies was eradicated from Great Britain. As a matter of fact, no case of the disease was detected in England or Scotland during the past twelve months, and the only cases reported during the year were in Wales. The total number of dogs attacked was six, but five other animals were destroyed in consequence of having been bitten by rabid dogs. No case of the disease has been detected in dogs since the second week of October last."

PRECAUTIONS TO BE TAKEN BY PERSON BITTEN. In the event of a bite by an animal supposed to be mad the wound should be cau-

terized as soon as possible with fuming nitric acid. This should be thoroughly applied to all parts of the wound, making sure that there are no pockets or recesses which escape the action of the acid. If such cauterization is carried out within twenty-four hours of the reception of the wound, the danger is very much lessened, and if done within a few hours the protection is absolute. In the absence of fuming nitric acid the hot iron or the thermo-cautery, or even strong antiseptics may be used, but experiments have shown that nitric acid is the most efficient. The invariable rule should be: *Cauterize as soon as possible, and in the meantime do everything to get the virus out of the wound*, by washing in an abundance of water, enlarging the wound and encouraging free bleeding by cupping or the application of ligatures around the limb above the site of injury. Osler advises that the wound be kept open for five to six weeks.

The animal which inflicted the wound *should in no case be killed but should be captured, if possible, and confined for observation*. In this way it is often possible to determine positively within a day or two whether the animal was really rabid, and much anxiety spared the bitten person. As soon as the animal dies the whole head should be cut off close to the shoulders, packed in ice and sent to the nearest laboratory for examination. In the State of Pennsylvania, the Laboratory of the State Live Stock Sanitary Board undertakes this work free of expense, and in the majority of cases a positive opinion can be given in twenty-four hours after the receipt of the head. Where the animal has been killed, either by intention or accident, a positive opinion cannot be given in many cases in less than from three to six weeks, as the result of inoculation must be waited for. The same is true where only a portion of the brain is sent, since the changes which indicate rabies that can be detected by the microscope are found only in the medulla oblongata, and in the ganglia found on some of the nerves. From these facts, the great importance of sending the whole head and neck will be seen.

DISPOSAL OF BODIES OF ANIMALS WHICH HAVE DIED OF RABIES. The flesh of animals which have died of rabies, or have been killed on account of it, is unfit for food. If possible, the carcass should be destroyed by burning, or be sent to a knacker's, where it is cooked in the process of utilizing it commercially. If this is not possible, it should be deeply buried under a layer of quick lime. The law of France allows the removal of the skin, and its sale after disinfection, which is done by immersing it in a 2 per cent. solution of sulphate of zinc, or in corrosive sublimate, two parts to 1,000.

DISINFECTION. All bedding used by an animal with rabies, and all remains of food, etc., should be destroyed by burning. Collars, chains, halters, blankets, feed-pans and other such articles should

be well washed with a 5 per cent. solution of carbolic acid, and exposed to the sun for two or three days after. Every part of the kennel, room or stall should be washed with the same, and after drying receive a thick coat of whitewash. In the case of horses, cows and such animals, particular attention must be paid to the feed and water troughs, as the chief source of contagion is the saliva, and these articles are especially apt to be contaminated. In all cases it is best to leave the kennel or stall vacant for two weeks, and in the meantime expose them to the sun and air as freely as possible.

COMMONWEALTH OF PENNSYLVANIA.

DEPARTMENT OF AGRICULTURE.

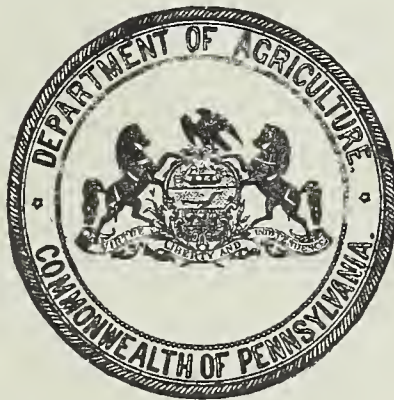
BULLETIN NO. 79.

RABIES,

BY

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of Pennsylvania.*



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